Modeling Notification

Dispatching DER off of Maximum Power During Study Case Creation

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This Modeling Notification provides Transmission Planners (TPs) and Planning Coordinators (PCs) with recommended modeling practices and considerations for modeling distributed energy resources (DERs) when dispatching DER at output levels other than the maximum power (P_{max}) in the powerflow case and in dynamic simulations. These recommendations are intended to help provide clarity and consistency in modeling practices to ensure that the expected response from DER is attained in stability simulations based on how the resources are modeled.

Primary Interest Groups

Transmission Planners, Planning Coordinators, MOD-032 Designees[1]

Background

As the penetration of DERs continues to grow across North America, it is becoming important to appropriately represent aggregate DER in planning assessments to study their impact on the bulk power system (BPS). When DERs are explicitly represented in a powerflow base model, their dispatch will be a key focus for developing base cases used for performing steady-state and dynamic simulations. As more resources are installed conforming to CA Rule 21[2] and IEEE Std. 1547-2018[3] requirements, these resources may be designed and equipped to provide active power-frequency control. However, based on relevant requirements[4] and study objectives, these resources may or may not be situated to actually provide that capability to the grid based on how they are dispatched. For example, although a DER may be equipped to provide primary frequency response, it may be dispatched at maximum available[5] active power at all times, thereby negating the ability to respond to declining frequency. Therefore, as DER is dispatched in the planning cases, it is important to ensure that the powerflow and dynamics models and parameter values are set up such the simulations match the expected response in the field for the conditions under study. This guideline provides information relevant to planners and modelers when developing base cases that include DER. The issues presented here are applicable to DER that are represented as either U-DER[6] or R-DER[7] (component of load in powerflow).[8] Refer to Figure 1 for an illustration of U-DER and R-DER representations in the steady-state and dynamics models.

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[1] MOD-032 Designees are designated by NERC to develop interconnection-wide planning base cases per Requirement R4 of MOD-032-1.

[2] CPUC: Interconnection (Rule 21). California Public Utilities Commission: http://www.cpuc.ca.gov/Rule21/.

[3] https://standards.ieee.org/findstds/standard/1547-2018.html.

[4] These could be local utility requirements, regional requirements, or other applicable standards or grid codes.

[5] "Maximum available power" refers to the maximum amount of power output from a resource at any given time. For variable energy resources, this value fluctuates based on, for example, wind speed and solar irradiance. This maximum quantity differs from the maximum power capability, which is a fixed value.

[6] Represented as a generator in the powerflow base case, with corresponding dynamic model.

[7] Represented as a component of the load in the powerflow base case, with corresponding representation in the composite load model.

[8] Refer to the existing DER modeling guidelines:
https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Reliability_Guideline_-_DER_Modeling_Parameters_-_2017-08-18_-_FINAL.pdf
https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Reliability_Guideline_-_Modeling_DER_in_Dynamic_Load_Models_-_FINAL.pdf

Summary of Dispatch and Corresponding Dynamic Model Settings

When the DER model is configured with the active power-frequency controls disabled in the dynamic model, the considerations described here are not relevant. Similarly, if the DER is dispatched at its P_{max} value in the powerflow base case (and corresponding dynamics parameter value), the considerations described here are not relevant. However, if the active power-frequency controls are enabled in the dynamics data and the resource is dispatched with P_{gen} less than P_{max}, the considerations described here should be used by planners and modelers. Table 1 summarizes this information, as well as some additional details.

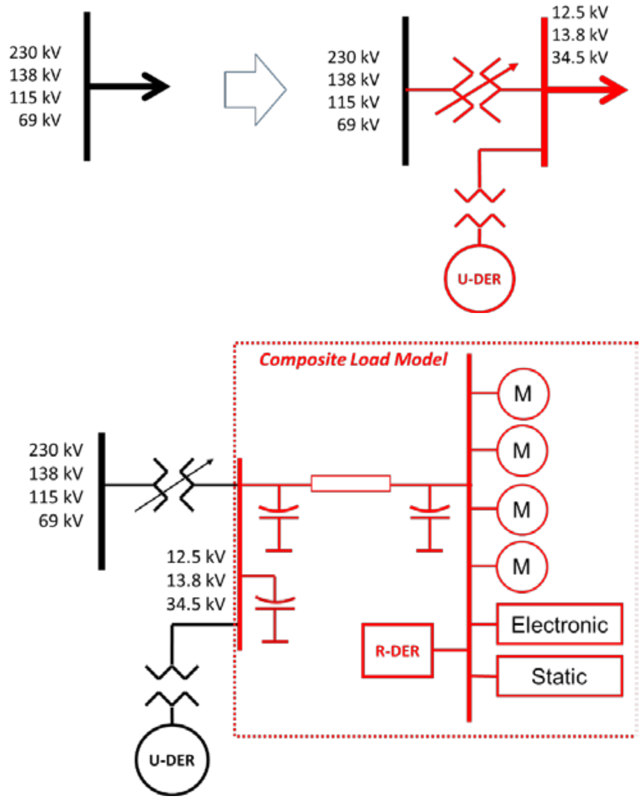

Figure 1: Representation of U-DER and R-DER

Table 1: DER Dispatch Situations		
Powerflow	**Dynamics Model P-F Controls**	**Outcome**
$P_{gen} = P_{max}$	Enabled	No action needed.
$P_{gen} = P_{max}$	Disabled	No action needed.
$P_{gen} < P_{max}$	Enabled	Need to ensure correct dynamics model parameters selection.
$P_{gen} < P_{max}$	Disabled	No action needed.

This notification uses the *DER_A* dynamic model as the model of choice for representation of individual (or aggregate) U-DER or aggregate R-DER in stability simulations. The concepts may also apply to other DER models used in stability studies; however, the *DER_A* is the recommended model for transmission-level planning assessments. Refer to the NERC Reliability Guideline: DER_A Parameterization[9] or the DER_A specification document[10] for more details on the *DER_A* model. Figure 2 shows the block diagram of the *DER_A* active power-frequency control blocks.

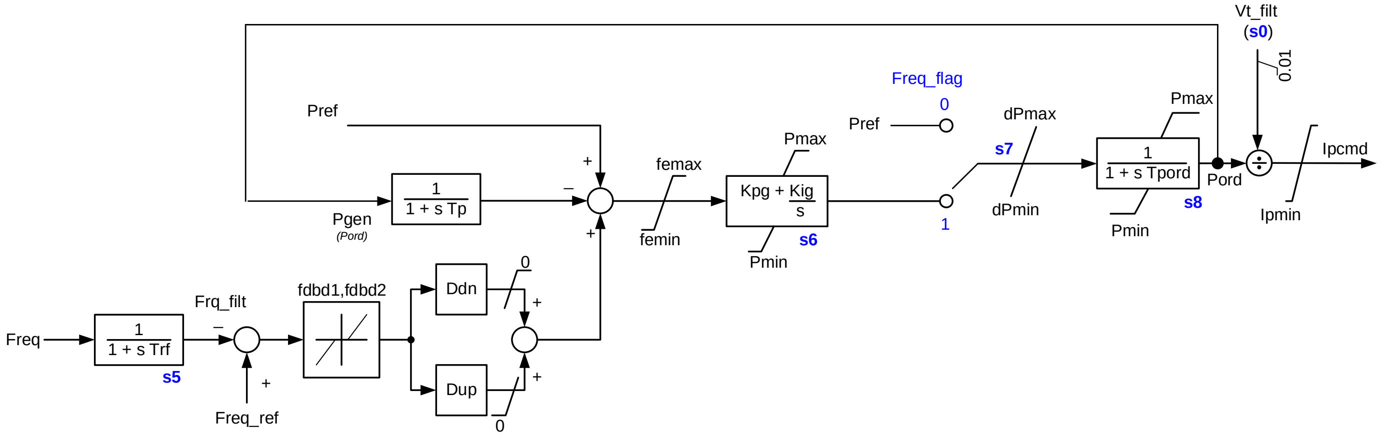

Figure 2: *DER_A* Active Power-Frequency Controls

In the *DER_A* model, active power-frequency controls are enabled when the *Freq_flag* is set to 1. If set to 1, the frequency error is limited by *femax* and *femin*, and passes through a PI controller with *Kpg* and *Kig* gains.[11] The *fdbd1* and *fdbd2* parameters represent the active power-frequency control deadband for overfrequency and underfrequency, respectively. The *Ddn* and *Dup* parameters represent overfrequency and underfrequency droop gains, respectively. The active power-frequency controls in the *DER_A* model may be applicable, and should be reviewed for the situations shown in Table 2.

[9] https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Reliability_Guideline_DER_A_Parameterization.pdf
[10] P. Pourbeik, "Proposal for DER_A Model," June 19, 2019. [Online]: https://www.wecc.org/Reliability/DER_A_Final_061919.pdf.
[11] These parameters govern the speed and magnitude of initial response following a detected frequency error (measured versus set point).

Table 2: *DER_A* Active Power-Frequency Controls	
Control Settings	**Represented Conditions**
Freq_flag = 0	Active power-frequency control is disabled.
Freq_flag = 1 fdbd1 <<< 0 and fdbd2 >>> 0	Frequency error deadbands[12] are set very large such that the closed loop active power-frequency response is disabled even if the frequency control flag is set to 1.
Freq_flag = 1 Ddn = 0; Dup = 0	Active power-frequency control is enabled; however, both droop gains are set to zero so the closed loop response is disabled. This is not a recommended modeling approach.
Freq_flag = 1 Ddn > 0; Dup = 0	Active power-frequency control is enabled. The DER model will respond to overfrequency conditions by reducing active power when frequency exceeds nominal frequency plus fdbd1. The DER model will not respond to underfrequency conditions. This may become a common modeling assumption moving forward, assuming DER has the capability and is programmed/set to provide downward response for overfrequency conditions.
Freq_flag = 1 Ddn = 0; Dup > 0	Active power-frequency control is enabled. The DER model will respond to underfrequency conditions by increasing active power when frequency falls below nominal frequency plus fdbd1. This requires available frequency responsive reserve (i.e., headroom) where the DER is dispatched less than maximum available power. DER model will not respond to overfrequency conditions. This modeling approach is not likely since operation of DER in this manner is also unlikely. Unless a specific study scenario warrants this setup, this modeling approach warrants review.
Freq_flag = 1 Ddn > 0; Dup > 0	Active power-frequency control is enabled. The DER model will respond to overfrequency conditions by reducing active power when frequency exceeds nominal frequency plus fdbd1. The DER model will also respond to underfrequency conditions by increasing active power when frequency falls below nominal frequency plus[13] fdbd1. Response to underfrequency events requires available headroom where the DER is dispatched less than maximum available power.

In most cases, at least in the near future, it is assumed that the active power-frequency controls will be disabled, or enabled for overfrequency but disabled for underfrequency (i.e., operated at maximum available active power). This assumption should be defined and modeled accordingly by TPs and PCs, based on data and information received by the DP or other relevant requirements.

If the DER is assumed to have frequency response capability to underfrequency events, then care must be given to coordinating the powerflow and dynamics data, which may require differing respective P_{max} values. Assuming a non-zero value for Dup, and assuming the resource is dispatched less than the P_{max} value in the powerflow, yet operating at maximum available power, then the P_{max} value in the DER_A dynamics data will need to be modified.

[12] The parameters fdbd1 should be a negative value; fdbd2 should be a positive value. Some programs may correct incorrect data, regardless of sign error.
[13] Because fdbd1 is negative, this should be a plus rather than minus.

For example, assume a mid-morning operating point is being modeled. The DER is dispatched to P_{gen} = 1 MW, its assumed maximum available output for these conditions. However, its maximum capability of P_{max} = 5 MW is stated in the powerflow model. Therefore, in the dynamics data, the corresponding P_{max} value in the DER_A dynamic model parameters should then be set to 1/5 = 0.2 (assuming that 5 MW is the value of MVA base used in the dynamic data).

Modeling Notification

Recipients of this Modeling Notification should review the following, which describes recommended modeling practices and considerations for stability studies involving aggregate DER modeling when the aggregate DER is dispatched at output levels less than the P_{max} value stated in the powerflow base case.

1. TPs and PCs should ensure that the active power-frequency controls for DER dynamic models, either as part of a U-DER (standalone model) or R-DER (component of composite load model), are set to represent the expected performance of the aggregate DER.
2. In situations where the active power-frequency controls are enabled in the dynamic model(s), TPs and PCs should ensure that any modifications to DER dispatch in the powerflow where $P_{gen} < P_{max}$ are modeled accordingly in the dynamic data.
    a. If DER is dispatched in the powerflow with $P_{gen} < P_{max}$ and assumed to be operating at maximum available active power output (i.e., maximum irradiance), then the active power-frequency controls for underfrequency conditions (i.e., Dup) should be set to 0 (disabled).
    b. If DER is dispatched in the powerflow with $P_{gen} < P_{max}$ and assumed to be operating with some frequency responsive reserve (i.e., less than maximum irradiance), then the active power-frequency controls for underfrequency conditions should be set accordingly (enabled).
        I. In this case, an appropriate value of P_{max} in the dynamic model will need to be assigned for each specific dispatch scenario, such that the correct assumption of maximum irradiance is defined. Note that changing the generator value of P_{max} in the powerflow data alone is not sufficient; the dynamic model parameter P_{max} should be modified accordingly as well. The powerflow P_{max} is not used in dynamic simulations.
3. TPs should coordinate with their DPs to ensure tracking (and use of engineering judgment) to estimate the vintage of DER installations. This information is useful for TPs and PCs to develop dynamic model parameter values for their planning assessments.
4. The MOD-032 Designees should develop processes and requirements for collecting DER data for inclusion in interconnection-wide base cases, and should ensure that the data provided meets a set of reasonability checks. This will ensure robust base cases that TPs and PCs will use as the starting point for their planning assessments.

For more information or assistance, please contact the [NERC Advanced System Analytics and Modeling Department](mailto:) (via email) or at (404) 446-2560.